

VCE Biology Units 3&4

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

1	☒ A	☐ B	☐ C	☐ D
2	☐ A	☒ B	☐ C	☐ D
3	☐ A	☐ B	☐ C	☒ D
4	☐ A	☐ B	☒ C	☐ D
5	☐ A	☐ B	☐ C	☒ D
6	☐ A	☒ B	☐ C	☐ D
7	☒ A	☐ B	☐ C	☐ D
8	☐ A	☐ B	☒ C	☐ D
9	☐ A	☐ B	☒ C	☐ D
10	☐ A	☐ B	☐ C	☒ D
11	☐ A	☐ B	☒ C	☐ D
12	☒ A	☐ B	☐ C	☐ D
13	☐ A	☒ B	☐ C	☐ D
14	☐ A	☐ B	☒ C	☐ D
15	☐ A	☒ B	☐ C	☐ D
16	☐ A	☐ B	☐ C	☒ D
17	☒ A	☐ B	☐ C	☐ D
18	☐ A	☐ B	☐ C	☒ D
19	☒ A	☐ B	☐ C	☐ D
20	☒ A	☐ B	☐ C	☐ D
21	☐ A	☒ B	☐ C	☐ D
22	☒ A	☐ B	☐ C	☐ D
23	☐ A	☐ B	☒ C	☐ D
24	☐ A	☒ B	☐ C	☐ D
25	☐ A	☐ B	☐ C	☒ D
26	☐ A	☐ B	☐ C	☒ D
27	☐ A	☒ B	☐ C	☐ D
28	☒ A	☐ B	☐ C	☐ D
29	☐ A	☒ B	☐ C	☐ D
30	☐ A	☒ B	☐ C	☐ D
31	☐ A	☐ B	☒ C	☐ D
32	☐ A	☐ B	☒ C	☐ D
33	☒ A	☐ B	☐ C	☐ D
34	☐ A	☒ B	☐ C	☐ D
35	☐ A	☐ B	☐ C	☒ D
36	☒ A	☐ B	☐ C	☐ D
37	☐ A	☒ B	☐ C	☐ D
38	☐ A	☒ B	☐ C	☐ D
39	☐ A	☒ B	☐ C	☐ D
40	☒ A	☐ B	☐ C	☐ D

Question 1 A

A is correct. Molecule 1 is a polypeptide chain. The amino acids in molecule 1 carry specific R-groups that help provide the specific shapes seen in higher levels of arrangement.

B is incorrect. Complementary pairing is seen in the DNA represented in molecule 2.

C is incorrect. Phosphate groups are a part of the nucleotides seen in molecule 2.

D is incorrect. The double helix in molecule 2 is arranged in an antiparallel fashion.

Question 2 B

B is correct. Molecule 1 is a polypeptide chain, which has amino acids as its constituent parts. Molecule 2 is DNA, which consists of nucleotides.

A is incorrect. Molecule 2 provides the blueprint for molecule 1.

C is incorrect. Both transcription and translation are required to build protein molecules.

D is incorrect. Molecule 1 is determined by the genetic information encoded by molecule 2.

Question 3 D

D is correct. The *trp* operon is a model of gene expression where a repressor protein detaches from the operator section of the operon because a lack of tryptophan in the environment triggers a conformational change in shape. This allows RNA polymerase to bind to the promoter section of the operon, leading to the transcription of the *trp* operon's structural genes.

A is incorrect. The repressor bound to the operator section of the gene will not allow RNA polymerase to bind to the promoter.

B is incorrect. When the repressor's shape is appropriate, it will bind to the operator, not the promoter.

C is incorrect. The structural genes need to be expressed for the bacteria to produce tryptophan.

Question 4 C

C is correct. A protein that functions at a quaternary level of arrangement is formed from more than one polypeptide chain bound together; for example, rubisco has around 16 polypeptide chains.

A is incorrect. Alternative splicing leads to different polypeptide arrangements for a single polypeptide.

B is incorrect. Ribosomes carry out the function of translation regardless of the mRNA sequence moving through it.

D is incorrect. Rubisco functions in the stroma of chloroplasts, not the extracellular environment.

Question 5 D

D is correct. Proteomics is the study of the structure and function of proteins and their interactions with each other in a cell. Proteins and their relationships can vary between different cells in a single organism due to the specificity of each cell.

A is incorrect. Genomics is the study of DNA.

B is incorrect. Biochemistry is the study of the general chemical interactions within organisms.

C is incorrect. Immunology is the study of disease.

Question 6 B

B is correct. Enzymes that cut DNA are called restriction endonucleases or restriction enzymes. In bacteria, these enzymes function as a defence against foreign DNA. In various areas of biotechnology, restriction endonucleases are isolated from the bacteria that produced them and used to cut DNA.

A is incorrect. Ligase enzymes splice DNA together.

C is incorrect. RNA polymerase is involved with DNA transcription.

D is incorrect. DNA polymerase is involved with DNA replication.

Question 7 A

A is correct. When expressed in a bacterium, the two genes originally on the plasmid would, when expressed in a bacterium, produce a product that enables them to survive both in ampicillin and tetracycline. The inserted gene disrupts the tetracycline gene and so bacteria with the recombined plasmid would only be able to survive in an environment of ampicillin.

B and **C** are incorrect. The tetracycline gene has been disrupted.

D is incorrect. Bacteria with the recombined plasmid would not survive on plate 3.

Question 8 C

C is correct. Polymerase chain reaction (PCR) is a process that produces large volumes of target DNA from small initial samples. Many conditions and factors are required in the process, including the bonding of primers to target complementary sections of DNA in the sample being tested. Once the primer is bound, the *Taq* polymerase binds to the primer and begins DNA replication.

A is incorrect. There would be too many binding sites with small primers, which would compromise specificity.

B is incorrect. The hydrogen bonds that hold the double DNA strands together are denatured with heat, not the phosphodiester bonds that hold the nucleotides together along a single polynucleotide strand.

D is incorrect. The chemicals required for all cycles, including nucleotides, are added prior to the commencement of the process.

Question 9 C

C is correct. After each cycle, the number of DNA strands produced by the PCR doubles. The progression of the DNA strands is shown below, where the cycles are indicated with arrows.

1 → 2 → 4 → 8 → 16 → 32 → 64

Therefore, there would be 64 strands after six cycles.

A is incorrect. There would be 16 strands after four cycles.

B is incorrect. There would be 32 strands after five cycles.

D is incorrect. There would be 128 strands after seven cycles.

Question 10 D

D is correct. Aerobic respiration is the catabolism of glucose and oxygen to produce energy (ATP), carbon dioxide, and water.

A and **B** are incorrect. These are incomplete lists of the products of aerobic respiration.

C is incorrect. ATP is a product of aerobic respiration, but glucose and oxygen are the reactants.

Question 11 C

C is correct. By using genetically modified organisms (GMOs), the corn farmer spends less on pesticides, the potato farmer wastes less produce and the salmon farmer is able to increase their yields.

A is incorrect. There is no information in the scenario that relates to the size of potatoes or antibiotic resistance in corn.

B is incorrect. There is no information relating to the longevity of salmon.

D is incorrect. There is no information relating to antibiotic use in potatoes or viral infections in salmon.

Question 12 A

A is correct. The substrate is made up of the chemicals that are present at the start of the reaction and the product is the chemical that is present at the end of the reaction. The catalyst is the enzyme that enables the reaction to occur, and a coenzyme is an organic factor that participates in the active site of the enzyme with the substrate. Therefore, the substrate is BPG, the product is G3P, the enzyme is G3PDH and the coenzyme is NADPH.

B, C and D are incorrect. These rows do not give the correct substrate, product, catalyst and coenzyme for the reaction.

Question 13 B

B is correct. A variety of factors affect the rate of an enzyme-controlled reaction. As the enzyme involved is a human enzyme, it would be expected to have an optimal functioning condition of pH 7 and 37°C. Lowering the pH to optimal conditions would decrease the time it takes for a colour change to occur, indicating a faster reaction.

A is incorrect. Increasing the temperature of the enzyme above the optimal temperature of 37°C would denature the enzyme.

C is incorrect. A smaller amount of the substrate will either not affect or decrease the rate of the reaction; therefore, this is not the factor that is most likely to reduce the rate of the reaction.

D is incorrect. A decrease in volume will not affect the reaction rate unless the reactants within the container increase in concentration.

Question 14 C

C is correct. Structure 5 is one of the cristae of the mitochondria, which greatly increases the inner membrane's surface area and the number of electron transport chains that can be located along the inner membrane.

A is incorrect. Glycolysis occurs in the cytosol.

B is incorrect. The Krebs cycle occurs in the matrix, which is structure 3.

D is incorrect. ADP is phosphorylated into ATP along the cristae.

Question 15 B

B is correct. Location 2 is the inter-membrane space, which serves as an environment where hydrogen ions can accumulate after NADH is oxidised by the electron transport proteins. The difference between the higher hydrogen concentration in the inter-membrane space and the lower hydrogen concentration in the matrix (location 3) allows the hydrogen to diffuse through ATP synthase to produce ATP.

A is incorrect. The proteins in the cristae are involved in the oxidation of NADH.

C is incorrect. Once enzymes are formed by the ribosomes (structure 4) within the mitochondria, they are functional and do not need to be stored.

D is incorrect. Structure 1 (the outer membrane) does not relate to structure 6 (the DNA).

Question 16 D

D is correct. Respiration is a process that produces CO_2 and constantly occurs in tomato plant cells. As the light intensity level increases, the rate of photosynthesis also increases, which removes CO_2 from the surrounding environment. The rate of photosynthesis eventually reaches a plateau when certain factors, such as the concentration of Rubisco, limit the photosynthetic process.

A is incorrect. Respiration occurs steadily, regardless of light intensity.

B is incorrect. At 20 lux, the increased level of light has started the process of photosynthesis, removing a small amount of CO_2 .

C is incorrect. At 40 lux, the rates of photosynthesis and respiration are equal.

Question 17 A

A is correct. Photorespiration is a wasteful process when Rubisco acts on O_2 rather than CO_2 . This typically occurs in C_3 plants that, unlike C_4 and CAM plants, are not well-adapted to extreme conditions. C_4 plants maintain a steady use of CO_2 by converting it into a 4-carbon compound before carbon fixation and, thus, can grow in more arid environments. CAM plants undergo the light-independent reaction at night.

B is incorrect. C_3 plants, not C_4 plants, immediately integrate CO_2 into a 3-carbon compound.

C is incorrect. C_3 and C_4 plants absorb similar levels of CO_2 during the day.

D is incorrect. CAM plants are suited to desert environments; C_3 and C_4 plants are not.

Question 18 D

D is correct. In the production of ethanol, biomass refers to a steady supply of carbon-rich compounds that glucose can be extracted from in high amounts, allowing ethanol to be produced anaerobically from the breakdown of glucose via fermentation. The best source of biomass is cellulose as it is a polysaccharide, meaning that it is a source of glucose and available in large amounts from plant material.

A, **B** and **C** are incorrect. These options would not provide an efficient amount of biomass compared to cellulose.

Question 19 A

A is correct. The addition of 10% ethanol to 90% petrol oxygenates the petrol, resulting in a 'cleaner' burn and reduced greenhouse emissions.

B is incorrect. Fermentation does not involve recycling existing stores of petrol.

C is incorrect. E10 fuel supplies energy to petrol-driven vehicles and its availability has no impact on the uptake of electric vehicles.

D is incorrect. The fermentation of biomass to produce ethanol and E10 fuel happens via industrial processes, not inside of a car engine.

Question 20 A

A is correct. These cells are involved in a variety of ways with the innate immune response. Neutrophils detect pathogens and act first when pathogens enter the body, macrophages phagocytose pathogens and eosinophils are involved in inflammation.

B, **C** and **D** are incorrect. Eosinophils are involved in inflammation. Lymphocytes are primarily part of the acquired immune response, though they can become part of the innate immune response.

Question 21 B

B is correct. Neutrophils are white blood cells that detect non-self markers and, in response, secrete cytokines. The subsequent inflammation attracts more cells such as macrophages, leading to phagocytosis.

A is incorrect. Eosinophils are granulated white blood cells that, when stimulated, destroy the target cell with secreted interleukins.

C is incorrect. Antibodies bind to antigens.

D is incorrect. Plasma B cells secrete antibodies.

Question 22 A

A is correct. The mast cells contain vesicles with histamines and, upon exposure to the peanut allergen, these histamines are released, causing an allergic response. The cells infected by the influenza type B virus will release interferons that signal neighbouring cells to inhibit viral replication in them.

B is incorrect. The peanut allergen binds to antibodies on the mast cells.

C is incorrect. Mast cells secrete histamines, not interferons.

D is incorrect. The infections are separate, so one does not stimulate the other.

Question 23 C

C is correct. The lymphatic system is where the lymphocytes are located, so it is involved in active immunity. The ducts provide a pathway for antigens to get to the nodes, allowing an immune response to be initiated.

A is incorrect. The valves are in the ducts, not the nodes.

B is incorrect. B and T cells stimulate adaptive (active) immunity, not inflammation.

D is incorrect. Mature B cells remain in the lymph nodes and T cells are mobile.

Question 24 B

B is correct. An antibody is a functional protein with four polypeptide chains that connect in a 'Y' shape. There are two light chains, and two heavy chains that connect with the light chains on the lower side of the Y branches. Both ends of the Y branches have complementary shapes to the same antigen. In this case, there would be two different antibodies formed against the two different antigens on the bacterium.

A and **C** are incorrect. The antibodies have different antigen binding sites on the same antibody.

D is incorrect. The light chains are on the wrong side of the Y.

Question 25 D

D is correct. Gaining antibodies across the placenta is a form of passive natural immunity. The mother has developed antibodies against an infection which will provide the infant with a short-term immunity against the same infection until its immune system develops enough to be functional.

A is incorrect. This involves the production of memory cells and is a form of long-term immunity.

B is incorrect. This is provided through vaccines and is a form of long-term immunity.

C is incorrect. This is provided by administering antibodies that have been manufactured in a laboratory to provide short-term immunity.

Question 26 D

D is correct. Cholera outbreaks are linked to the cleanliness of water. As water is used for many daily tasks such as drinking, cooking, cleaning, washing and using the toilet, using clean water should be the top priority when reducing the incidence of cholera.

A is incorrect. Clean water is required to reduce the incidence of cholera; the food supply is not relevant.

B is incorrect. Sewage that enters the river upstream will contaminate the drinking water supply when it flows downstream.

C is incorrect. Food should not be washed in water taken directly from the river as cholera may be present in the water.

Question 27 B

B is correct. When a new disease appears in a population, the individuals will not have any immunity. Thus, during the European colonisation of Australia, the smallpox virus was passed on to First Nations peoples with devastating effects.

A is incorrect. The human immune system can respond to any antigen.

C is incorrect. Lymphocytes are part of every individual's immune system.

D is incorrect. The presence of cows in Australia is not relevant as smallpox was contracted through human-to-human contact.

Question 28 A

A is correct. The generation of monoclonal antibodies begins by injecting the antigen into a mammal such as a mouse. The mouse then develops immunity against the antigen and, when the specific B cells are extracted and hybridised with cultured cancer cells, a supply of the necessary antibody can be obtained.

B is incorrect. Antigens bind to receptors on the surface of B cells.

C is incorrect. Mature B cells are combined with cancer cells.

D is incorrect. B cells, not cancer cells, are needed to make antibodies.

Question 29 B

B is correct. Based on the information given, Pembrolizumab blocks PD-L1 on the surface of the cancer cell. This means that the NK cell no longer detects the cancer cell as 'self' and so will proceed to destroy it.

A is incorrect. The NK cell will reject, not accept, the cancer cell.

C is incorrect. Only the cancer cell will undergo apoptosis.

D is incorrect. Localised cells will also have Pembrolizumab bind to their PD-L1 markers, leading to possible side effects.

Question 30 B

B is correct. Viruses reproduce quickly and in large numbers. As a result, mutations also occur quickly in the viral genomes. Occasionally, a mutation will lead to a virus that contains different antigens, causing the virus to spread more successfully as there is not any immunity against this strain in the population. This is known as antigenic drift.

A is incorrect. Influenza is not bacterial.

C is incorrect. Memory cell levels remain high for a long period, but there are no memory cells for a previously unencountered strain.

D is incorrect. Seasonal flu shots reduce the chance of contracting influenza, not the development of possible side effects of the vaccine.

Question 31 C

C is correct. A gene pool is the sum of all alleles in a given population at a given time. If more individuals are in the population, the gene pool will become larger and be less susceptible to change than the gene pool of a smaller population. A large population of individuals immigrating to a new area with an existing low population will dramatically change the existing gene pool.

A is incorrect. One mutation in a population will not significantly change the gene pool.

B is incorrect. Even though the population has dropped by 50%, there are still 2500 individuals present, so a random event such as a cyclone is unlikely to significantly change the gene pool.

D is incorrect. Releasing 10 individuals into a population of 1000 individuals will not significantly change the gene pool.

Question 32 C

C is correct. Like many other organisms, dogs have been selectively bred for a very long time. Ancestral dogs that had desirable qualities, such as friendliness and intelligence, were bred with other dogs with desirable qualities to produce offspring that were thus more likely to display these qualities.

A is incorrect. The selection for specific qualities was made by humans choosing certain factors, not the environment.

B is incorrect. Evolution is generally associated with natural phenomena.

D is incorrect. Genetic drift refers to the change in gene pools due to unpredictable events.

Question 33 A

A is correct. Index fossils are usually easy to recognise and fossilise and are found in a relatively short time period. For these reasons, they can be used as a reference point to determine the relative age of other fossils. In this case, fossil W is the most appropriate index fossil as it is only found in one strata layer in each of the four locations.

B is incorrect. Fossil X is found in more than one strata layer in location 2.

C is incorrect. Fossil Y is found in more than one strata layer in locations 1, 3 and 4.

D is incorrect. Fossil Z is only found in location 4.

Question 34 B

B is correct. A vestigial structure is a structure present in an individual that serves no purpose but shows evidence of their ancestral past. Whale pelvic bones are one such structure.

A is incorrect. Transition fossils show evidence of structures that are shared between certain groups.

C is incorrect. Structural morphologies are variations within a particular group.

D is incorrect. Faunal succession shows a trend of how one organism succeeds another over time.

Question 35 D

D is correct. *Australopithecus afarensis* is an ancestral hominin that shares features with any organisms placed in a higher level of classification. The hierarchical levels are as follows: hominin, hominid, hominoid, primate, mammal.

A, B and C are incorrect. These levels of classification all share features with each other.

Question 36 A

A is correct. The diagram shows that species 1 and 2 have more homologous, darker regions than the other samples. There is only a difference of one small white band (in species 2), which means they would have the most recent common ancestor. Species 3 shows more homology to species 1 and 2 compared to species 4, and so would be more closely related to them.

B is incorrect. All four species would all be similarly different for this phylogenetic tree.

C is incorrect. Species 1 and 2 are the most similar, not species 3 and 4.

D is incorrect. Species 3 seems more closely related to species 1 and 2 and so should be linked to them more than what is shown here.

Question 37 B

Mitochondrial DNA mutates at a set rate and can be used as a molecular clock as it only shows variation due to mutation. This means that a group that displays a small number of differences in their mtDNA when compared to another group would have a more recent ancestor. Therefore, Indigenous South American peoples would have appeared most recently as shown by the 30 mtDNA differences; then Southern Asian peoples with 80; then Indigenous Australian peoples with 100, then Indigenous African peoples with 300.

Question 38 B

B is correct. A systematic error is one that occurs to the same extent each time the experiment is conducted. For example, if a machine used in the experiment is not calibrated correctly, the obtained results will be incorrect by the same amount each time. However, if the other aspects of the experiment are completed without errors, high precision can still occur. This is shown by all the results clustered in one area away from the intended area. Target 2 shows all the results clustered together slightly down and to the left from the centre of the target.

A is incorrect. This target represents an experiment with no systematic errors and high precision.

C and **D** are incorrect. These targets represent experiments with low precision, not high precision.

Question 39 B

B is correct. Accuracy refers to how close the results are to the true value. In this case, an accurate result would be shown by the crosses hitting the middle of the target. Target 1 does this with all trials; however, the average of the crosses on target 3 would also hit the middle of the target, making it accurate as well.

A and **D** are incorrect. Target 2 has a systematic error, so it is inaccurate.

C is incorrect. The average of the crosses on target 4 would be skewed away from the middle of the target.

Question 40 A

A is correct. The data shows that there is a very low chance of being admitted to hospital due to reinfection with a new strain of COVID-19 after vaccination. The average percentage of hospital admissions is approximately 0.4%, which equates to about 1 in 200 vaccinated individuals in the sample.

B is incorrect. For both the Pfizer and AstraZeneca vaccines, individuals who have received the second vaccine have a lower percentage of hospital admissions.

C is incorrect. An individual is more than twice as likely to be admitted to hospital after having the Pfizer vaccine compared to the AstraZeneca vaccine.

D is incorrect. A control group is not necessary because the two groups of data can be compared to each other.

SECTION B**Question 1 (8 marks)**

a.

Process	Process name	Molecule	Molecule name
1	transcription	1	DNA
2	RNA processing	2	pre mRNA
3	translation	3	(mature) mRNA

3 marks

*Award 1 mark for 1–2 correct names.**Award 2 marks for 4–5 correct names.**Award 3 marks for 5–6 correct names.*

- b. In process 2, introns are removed from the DNA and exons are joined together to make a smaller molecule. 1 mark
A methylated cap and poly A tail are added to the molecule to stabilise both ends. 1 mark
- c. peptide sequence: Leu – Val – Leu – Met – Leu – Glu 2 marks
Award 1 mark for at least 3 correct peptides.
- d. ribosomes, the rough endoplasmic reticulum, the Golgi apparatus, a vesicle 1 mark

Question 2 (7 marks)

a.

Part	Name	Function
3	protospacer adjacent motif (PAM) sequence	the location of the specific section on the target DNA that holds the DNA onto the CRISPR complex
4	target gene	has a complementary sequence to guide RNA
5	guide RNA (gRNA)	RNA that has a specific sequence determined by CRISPR to guide the Cas9 enzyme to a specific site on the target DNA

3 marks

1 mark for giving the correct name and function of each part.

- b. Identify a unique sequence in the salinity susceptibility gene and, using a vector, add the CRISPR-Cas9 complex to plant cells that contain this gene. 1 mark
Design synthetic guide RNA to be complementary to the unique gene sequence that will anneal to the target DNA and bind to the salinity susceptibility gene. 1 mark
Use the CRISPR-Cas9 complex to cut the salinity susceptibility gene to disrupt the gene or block its expression. 1 mark
- c. If the gene that makes a plant susceptible to salinity is disrupted, it cannot be expressed. Therefore, the plant may be able to survive in soils that are affected by salinity. 1 mark

Question 3 (9 marks)

- a.** Mix the gene of interest with a restriction enzyme that cleaves the gene on either end, liberating the sticky-ended fragments on both ends of the gene. 1 mark

Mix a plasmid with the same restriction enzyme, which cuts the plasmid once and thus liberates the sticky-ended fragments on both sides of the cut. 1 mark

Mix the gene of interest and plasmid together with a ligase enzyme so the complementary sticky-ended fragments anneal to form the recombinant plasmid. 1 mark

- b.** There are two Bam HII sites as the new fragment has complementary binding sites to Bam HII on either end of the gene to be inserted. 1 mark

The inserted gene of interest has an EcoRI binding site; when it is spliced into the plasmid, the plasmid gains a second EcoRI binding site. 1 mark

- c.** Any two of:

- Add the DNA at the negative end of the gel.
- Apply a voltage/current across the gel.
- Place the gel in a buffer solution.

2 marks

1 mark for each correct condition.

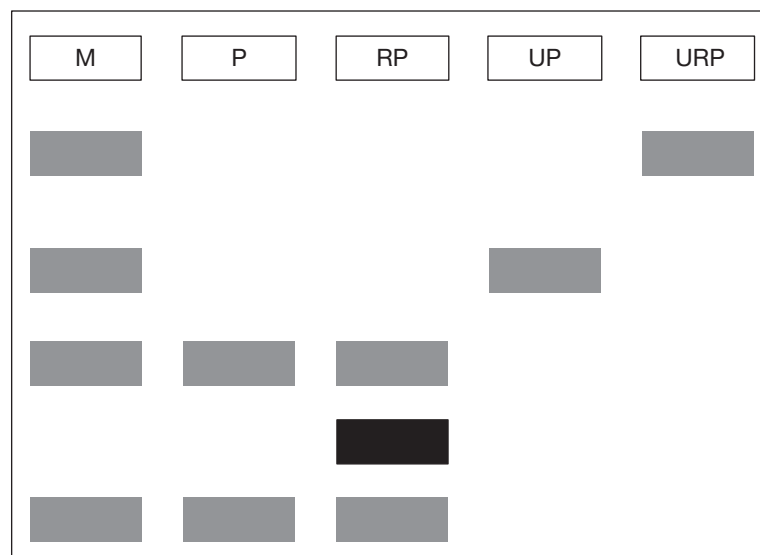
- d. i.** The size of the inserted gene is the difference between the unrestricted recombinant plasmid size (URP = 1.5 kilobases) and the original unrestricted plasmid size (UP = 1 kilobase).

$$1.5 - 1 = 0.5 \text{ kb}$$

Therefore, the inserted gene is 0.5 kb.

1 mark

- ii.**



1 mark

1 mark for drawing the 0.5 kb inserted gene fragment between the other two fragments in the RP lane.

Question 4 (8 marks)

a. Any two of:

- water
- appropriate pH
- light intensity
- ideal temperature

2 marks

1 mark for each condition.

b. i. E and F

1 mark

ii. D

1 mark

iii. E and F

1 mark

iv. E and F

1 mark

c. Trials 1 and 5 are comparable.

1 mark

All of the conditions in these trials are the same except for light intensity.

1 mark

Question 5 (6 marks)

a. Approximately one third of the gut microbiome of babies delivered vaginally consists of *Bifidobacterium* compared to approximately one tenth of the biome of babies delivered by caesarean section (C-section).

2 marks

1 mark for identifying Bifidobacterium.

1 mark for discussing how this differs between the two delivery methods.

b. Any two of:

- reduces the chance of pathogens entering the body and causing sickness
- reduces the chance of pathogens growing the surface of the body and causing disease
- assists with the uptake of nutrients
- assists with the production of chemicals needed by the body

2 marks

1 mark for each point.

c. 1. *Lactobaccilus* maintains acidity in areas like the stomach to help with digestion.

1 mark

2. *Bifedobacterium* helps to break down fibre (cellulose).

1 mark

Note: Responses must provide an appropriate function for each bacterium.

Repeating information from the stem is not sufficient to earn a mark.

Question 6 (9 marks)

a. A virus is a protein shell (capsid) containing RNA or DNA.

1 mark

b. For example, any one of:

- Appropriate testing: The science behind the vaccine should be supported with tests that provide data showing the vaccine is effective.
- Success rate: The vaccine should provide immunity for most individuals.
- Minimal side effects: The vaccine should work without making the recipient unwell.
- Cost: The cost should not be prohibitive in order to ensure equal access to the vaccine.
- Need: If the disease is affecting the population significantly, then there may be a need for a vaccine.
- Acceptance: The general public needs to embrace the need for a vaccine.

2 marks

1 mark for identifying an appropriate factor.

1 mark for explaining the factor.

Note: Any reasonable factor with an appropriate explanation should be accepted.

c. Free floating antigen will bind to a complementary receptor on the surface of a naïve B cell.

1 mark

The selected B cell then clones and differentiates into B plasma cells and B memory cells.

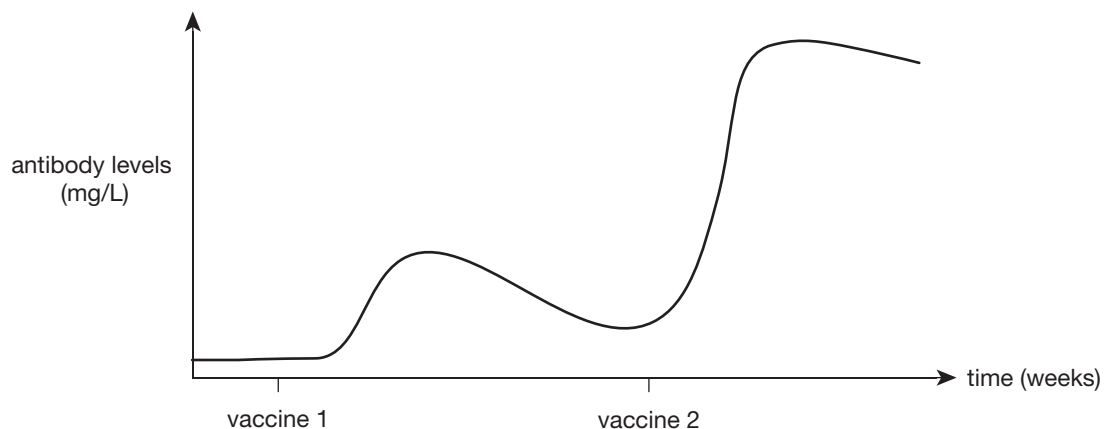
1 mark

The B plasma cells secrete antibodies that bind to the antigen, which is destroyed, and the memory cells remain in the body as a defence against future attacks.

1 mark

Note: Helper T cells can be discussed along with antigen-presenting cells (APCs), but it is not necessary in this scenario.

d.



3 marks

1 mark for drawing two peaks with the second peak higher than the first peak.

1 mark for drawing the second peak steeper than the first peak.

1 mark for showing a lag before the antibodies rise after the first vaccine and an immediate increase after the second vaccine followed by a slight decrease after the second peak.

Question 7 (7 marks)

- a.** Genetic variation in beak size would have existed in the ancestral population of finches that originally inhabited the island. 1 mark
- A selective advantage would have occurred for the larger, stronger beaks in an environment of hard-shelled seeds because the seeds are easier to break open with that type of beak. 1 mark
- Finches with larger, stronger beaks are then more likely to survive to reproductive age and pass the advantageous traits on, increasing the dominance of large, strong beak phenotypes in the gene pool. Thus, the large, strong beak becomes the predominant phenotype for this population of finches. 1 mark
- b.** **Galápagos finches:** These species are the result of allopatric speciation. 1 mark
- An ancestral population of finches were separated into different areas by geographical barriers and the different selection pressures in each area led to different species. 1 mark
- Howea palms:** These species are the result of sympatric speciation. 1 mark
- An ancestral population of *Howea* palms was located in the same geographical area but in different niches within that area. The different niches offered different selection pressures that led to different species. 1 mark

Question 8 (9 marks)

- a.** Any two of:
- rapid burial or covered by sediments to evade scavenging
 - a low-oxygen environment to reduce decomposition
 - cold temperature at the bottom of waterways to reduce decomposition
 - undisturbed to allow the fossilisation process to occur
- 2 marks
1 mark for each correct condition.
- b.** Uranium decays at a known rate and has a half-life of 700 million years. By determining the amount of uranium in the *Australotitan cooperensis* fossil (or in the volcanic rock near the fossil) and comparing it to the amount of uranium that would have been present when the rock was formed, the absolute age of the fossil can be discovered. 1 mark
- If there was one unit of uranium originally in the rock when formed and the volcanic rock near the fossil when it was found contained 0.5 units of uranium, the fossil would be 700 million years old. If the volcanic rock near the fossil contained around 0.9 units of uranium, the fossil would be closer to 100 million years old. 1 mark
- c.**
- i.** Bigger bones usually belong to bigger organisms. The excavated hip and leg bones could be compared to the bones of modern-day organisms, allowing the size of *Australotitan cooperensis* to be estimated. 1 mark
- ii.** This technology will give an idea of the size and structure of the fossil. If the discovered fossil is different to other known fossils, it could be hypothesised to be a different species. 1 mark
- d.**
-
- ```

graph LR
 Root --- Asian[Australian sauropods]
 Root --- Node1
 Node1 --- Titanosaurians[titanosaurians]
 Node1 --- Node2
 Node2 --- OtherAus[other Australian sauropods]
 Node2 --- Australotitan[Australotitan cooperensis]

```
- 1 mark

- e. Sauropods evolved when the land masses of Australia, South America and Asia were still connected, then dispersed to different areas on that land mass. 1 mark
- When the continents separated, the sauropods were isolated from each other and evolved into the different species found on each land mass. 1 mark

**Question 9 (7 marks)**

- a. Denny's finger bone was found in a cave where Denisovans and Neanderthals co-habited, allowing relations between the two groups to occur. 1 mark
- 40% of Denny's genome was Denisovan and 40% was Neanderthal. 1 mark
- b. The limit to radiocarbon dating is around 50 000 years because, at this time, there is very little carbon left in the sample, causing this dating method to lose accuracy. 1 mark
- Any one of:
- The mutation rate of mtDNA could be used to date Denny as this is applicable beyond 50 000 years.
  - A radioisotope that has a slightly longer half-life than carbon could be used to date Denny.
- 1 mark
- c. Mitochondrial DNA sequencing showed that Denny's mitochondrial DNA came from a Neanderthal. As mitochondrial DNA is inherited down the maternal line, the Neanderthal was Denny's mother. Thus, the Denisovan was Denny's father. 1 mark
- d. i. Neanderthals and Denisovans are genetically distinct and inhabited very different areas for hundreds of thousands of years. Thus, it is likely that they were different species because the time frame would allow DNA differences to accumulate to a significant enough point to cause the two species to diverge from each other. 1 mark
- ii. A Neanderthal and a Denisovan bred to produce Denny, implying that they were able to produce offspring and thus suggesting that they were the same species. 1 mark

**Question 10 (10 marks)**

- a. i. Any four of:
- the concentration of 1,3-Bisphosphoglycerate
  - the concentration of enolase and pyruvate kinase
  - temperature (37°C)
  - starting pH (pH 7)
  - the time in which each trial is conducted (five minutes)
- 2 marks
- Award 1 mark for 1–2 correct factors.*
- Award 2 marks for 3–4 correct factors.*
- ii. concentration of phosphoglycerate kinase (PGK) 1 mark
- iii. rate of change in pH after five minutes 1 mark

- b. i.** to ensure that the change in the concentration of PGK (independent variable) is the reason for the rate of the change in pH (dependent variable) and not some other factor 1 mark
- ii.** 4 mmol 1 mark
- The results of all four trials using 4 mmol of PGK are within 0.2 minutes of each other; the results of the trials using other concentrations vary more than this. 1 mark
- c.** Inhibitor A is competitive and inhibitor B is non-competitive. 1 mark
- Inhibitor A is competitive as it has less of an inhibitory effect at high substrate concentrations; increasing the substrate concentration decreases the proportion of the inhibitor that is available to compete for the active site of enolase. 1 mark
- Inhibitor B is non-competitive as its effect levels off at a lower reaction rate than the control because inhibitor B binds to a site away from the active site. Thus, the same number of enzymes will be inhibited at higher substrate concentrations. 1 mark